Chapter 5
COVID-19 Optimization-Based Vibration Controller for a Flexible Manipulator

Mehmet Mert İlman
https://orcid.org/0000-0001-7664-5217
Manisa Celal Bayar University, Turkey

Yılmaz Seryar Arıkuşu
Manisa Celal Bayar University, Turkey

ABSTRACT

Flexible manipulator real-time vibration control methods are effective, but finding the right control gain is difficult. The reason for this is that traditional approaches are not permitted by up-to-date and novel architectures. Current population-based meta-heuristic optimization approaches, on the other hand, can provide solutions for such challenges, as they are inspired by many natural phenomena. Therefore, in the study, the Coronavirus herd immunity optimization (CHIO) method, inspired by the herd immunity mechanism, which is a COVID-19 control method, was used for the optimization of a flexible manipulator control gains. Gray-wolf-optimizer (GWO), another up-to-date population-based algorithm, and traditional particle swarm optimizer (PSO) were used to compare the success of the method. The findings reveal that when it comes to optimizing the vibration controller gains of flexible manipulators, CHIO can outperform its contemporary and traditional competitors.

DOI: 10.4018/978-1-6684-5887-7.ch005

INTRODUCTION

Flexible manipulators created using light and agile links are a field that is currently being studied, as they can work with heavier payloads, consume less energy and are better suited for human-robot interaction compared to traditional rigid manipulators. It has applications in numerous fields such as space, nuclear energy, and medicine as a result of these features. However, its advantageous flexible structure is also very susceptible for vibration. As a result, vibration control of flexible manipulators is required for a successful application. Studies on this topic can be divided into two groups as real-time (closed-loop) and offline (open-loop). In open loop vibration control, Yavuz et al. (2016) succeeded in controlling vibration by establishing a relationship between the natural frequency of the structure and the time parameters of the motor input. Furthermore, this rule association, which was first developed through observation, was turned into a more generalizable state with the use of machine learning and several scenarios in the previous study (Ilman et al., 2022). According to the rule relation, setting the deceleration and acceleration periods of the motor input to be twice the natural vibration period of the structure is sufficient to dampen the vibration by 90%. Despite the fact that this method is convenient, it does not guarantee against disturbing inputs, which is a drawback that should not be overlooked. Fortunately, this is where real-time vibration control methods come into play. However, real-time vibration control also has its own drawbacks and challenges. A downside is the use of costly equipment such as sensors and controllers. Given that the structure's motion control is already been established, integrating vibration control into the motion control while avoiding disruption might be cited as an example of a challenge. While vibration control seeks to manage the structure's flexible movement, motion control aims to control its rigid movement. Since vibration sensors (e.g., accelerometers, strain gauges) do not provide information on the system's rigid movement, studies have underlined the necessity of utilizing more than one sensor in vibration control (Mohamed et al., 2005). However, the control architecture developed in a recent work (Ilman et al., 2022) shown that vibration control with a single sensor can be successfully implemented, ensuring that rigid motion is not disturbed. In this way, vibration control is completely separated from motion control. As a result, vibration control can be simply integrated into motion control. Furthermore, the study found that vibrations that cannot be eliminated by open-loop control can be dampened, which are caused by end effector forces that can occur while holding or releasing loads, such as in pick-and-place equivalent applications.

However, there are issues in real-time vibration control other than disturbing input that need to be addressed. The uncertainty of the payload information that the structure will carry, or the uncertainties that a structure with more than one

Related Content